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The role of quadratus lumborum asymmetry in the occurrence of lesions in the lumbar vertebrae of cricket fast bowlers

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Abstract

In cricket fast bowlers an increased incidence of stress fractures or lesions in the L4 pars interarticularis is observed, which shows a strong statistical correlation with the presence of hypertrophy in the contralateral Quadratus Lumborum (QL) muscle. This study aims to find a physical explanation for this correlation.

A mathematical model was used to estimate the forces and moments on the L3 and L4 vertebrae in six postures attained during fast bowling. These forces and moments were used in finite element models to estimate the stresses in the pars interarticularis. Two scenarios were examined per posture: symmetric QL muscles, and right QL muscle volume 30% enlarged. Influence of muscle activation was also investigated.

QL asymmetry only correlates with significant stress increases when stress levels are relatively low. When stress levels are high, due to extreme posture or muscle activation, asymmetry only causes small stress changes, suggesting that asymmetry is not the cause of stress fractures in the pars. There are even indications that asymmetry might help to reduce stresses, but more detailed knowledge of the size and activation of the lumbar muscles is needed to confirm this.

Keywords: Cricket fast bowlers; Pars interarticularis; Quadratus lumborum asymmetry; Fractures; Lumbar spine; Finite element modelling; Musculoskeletal modelling

1. Introduction

Low back injuries are common amongst cricket fast bowlers [1], in particular lumbar disc degeneration [2,3] and stress fractures or lesions of the lumbar vertebrae. Stress fractures often occur in the pars interarticularis as it is usually the narrowest region of the neural arch. In the general population pars interarticularis fractures have an occurrence rate of about 5% [4,5], most commonly in the lowest lumbar vertebra, L5 [4]. However, amongst elite fast bowlers occurrence rates of 10–50% are commonly reported in the literature [6]. Bartlett et al. [6] and Elliott [7] have given extensive overviews of the relevant literature on bilateral fractures in the partes interarticulares of fast bowlers, particularly at L5, and on unilateral fractures at many levels including L4. Unilateral fractures are predominantly found on the non-dominant side to the bowling arm [3,7,8] and often over multiple levels [3]. However, fractures at multiple levels may not always have a common cause, as Engstrom [9] showed that pre-existing L5 defects are not related to pars lesions at L4. Key factors that increase the risk of back injuries have also been reported, for example by Elliott [7] and by Portus et al. [10,11], but the exact mechanics behind the relationship between these factors and the occurrence of lesions are not always known [3,7]. The main factors identified by Elliott [7] were: (a) large shoulder counter-rotation, trunk twisting and lumbar movement, which are all key features of the mixed technique of a front-on back foot placement and a side-on shoulder alignment [12]; (b)

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high ball release because of a straight leg at front foot impact which results in higher ground reaction forces; (c) incorrect rehabilitation; (d) overuse such as long bowling spells and a large number of games in a season; (e) physical capacities such as poor hamstring flexibility; (f) muscle asymmetry. In particular, Engstrom et al. [13] have linked asymmetry of the Quadratus Lumborum (QL) muscle to stress fractures of the pars interarticularis.

It is this relationship between QL asymmetry and pars fractures which our study focuses upon. In the study by Engstrom et al. [13], an increased incidence was reported of unilateral lesions in the pars interarticularis of the L4 vertebra of young elite fast bowlers. Fractures occurred exclusively on the non-dominant side to the bowling hand and in the bowlers with fractures the QL on the side of the bowling hand was up to 30% larger. This large asymmetry in muscle volume was not noticed in bowlers without fractures. As yet there is no physical explanation for this strong association. The relationship between QL asymmetry and pars fractures could be explained by any of the following three hypotheses:

1. The bowling technique of these cricketers is causing unilateral hypertrophy (one-sided increased muscle growth) of the QL, which in turn causes an increase in the stress levels in the pars, eventually leading to fractures.
2. The bowling technique of these cricketers is causing both QL hypertrophy and increased stresses in the pars that lead to fractures, but the two effects are not physically related.
3. The bowling technique of these cricketers is causing increased stresses in the pars and the body develops a QL hypertrophy as a reaction to the high stresses in the pars, in an attempt to change the 'force flow' through the pars and reduce the stress levels.

No other mention of the association between QL asymmetry and pars fractures could be found in the literature. As mentioned, lumbar pars interarticularis fractures are common amongst fast bowlers, at many vertebral levels, both unilateral and bilateral, and there are many factors involved in the occurrence of these fractures. However, the aim of this study is specifically to examine the potential biomechanical influence of QL asymmetry in the occurrence of unilateral pars interarticularis fractures in the L4 vertebra of fast bowlers. Although finite element modelling has been used before to study pars interarticularis fractures, to our knowledge this is the first study to use finite element modelling to study the influence of muscle action on the stresses in the pars.

2. Method

A musculoskeletal finite element model (FEM) was developed to assess the potential of the QL to influence the stresses in the pars, for a range of relevant body postures that have been described in the literature. A previously developed mathematical model [14], based on the lumbar spine of the Visible Man [15], was used to predict the direction and magnitude of the muscle forces and moments acting on the L4 vertebra of the bowlers. For each posture two scenarios were compared: in the first one the Physiological Cross-Sectional Area (PCSA) of the left and right QL were equal, in the second one the PCSA of the right QL was increased by 30%. The results were imported into a FEM of an L4 vertebra, which estimated the stresses occurring in the pars for both scenarios.

2.1. Postural analysis

When looking at L4 from the posterior view (Fig. 1), it appears that any fractures in the left pars (for a right-handed bowler) are most likely to occur when the zygapophysial joints (z-joints) on the left side are impacted. This happens when the spine is twisted to the right, extended or bent to the left. Burnett et al. [12] described the postures a fast bowler goes through from back foot impact (BFI) to ball release (REL). We decided to focus on the postures around the moment of front foot impact (FFI) and the postures between FFI and REL. FFI occurs between 74% and 80% of the time from BFI (0%) to REL (100%). Table 1 describes all postures investigated. It shows that at the moment of ball release the most 'extreme' posture occurs. The moment of FFI is inter-

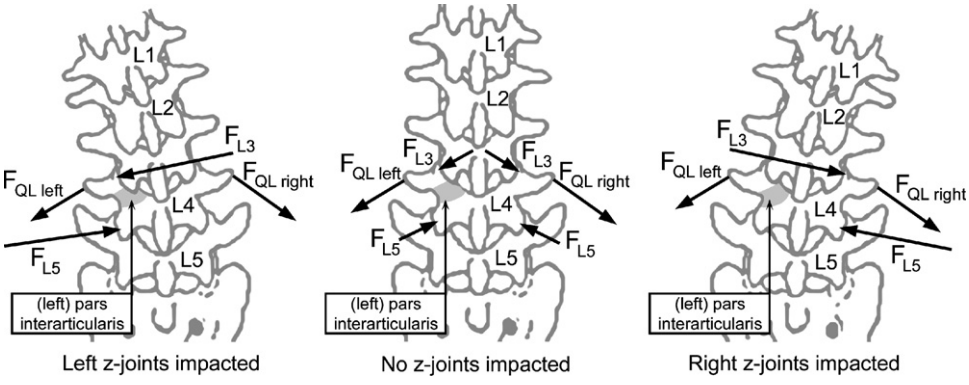

Fig. 1. Possible forces on the L4 posterior elements. The pictures show the forces exerted on L4 by the left and right QL and by L3 and L5 via the z-joints, in case the left z-joints are impacted (left picture), no z-joints are impacted (middle picture), or the right z-joints are impacted (right picture). Not shown are the forces exerted by other muscles and the forces and moments transmitted through the IVD.